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Importance of Drechslera maydis on Seed of Crops Other Than Maize

by

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No. 1. PAUL NEERGAARD: Seed-borne diseases. [Inspection for quarantine in Africa.] — Handbook for Phytosanitary Inspectors in Africa: 380—393. Lagos, Nigeria. 1969.

No. 2. PAUL NEERGAARD: Seed pathology of rice. — Plant Disease Problems. Proc. First International Symposium on Plant Pathology, New Delhi: 57—68. 1970.

No. 3. S. B. MATHUR & PAUL NEERGAARD: Seed health testing of rice II. Seed-borne fungi of rice in Philippines, India, Portugal and Egypt. Investigations on Trichoconis padwickii. — Plant Disease Problems. Proc. First International Symposium on Plant Pathology, New Delhi: 69—81. 1970.

No. 4. P. W. RAHALKAR & PAUL NEERGAARD: Studies on Aureofungin as seed treatment in controlling seed-borne fungal diseases. — Hindustan Antibiotics Bull. 11: 163—165. 1969.

No. 5. PAUL NEERGAARD: Seed pathology, international co-operation and organization. — Proc. Int. Seed Test. Ass. 35: 19—42. 1970.

No. 6. M. A. BENOIT & S. B. MATHUR: Identification of species of Curvularia on rice seed. — Proc. Int. Seed Test. Ass. 35: 99—119. 1970.

No. 7. RAM NATH, PAUL NEERGAARD & S. B. MATHUR: Identification of Fusarium species on seeds as they occur in blotter test. — Proc. Int. Seed Test. Ass. 35: 121—144. 1970.

No. 8. RAM NATH, PAUL NEERGAARD & S. B. MATHUR: Drechslera longirostrata (Subram.) comb. nov. in seeds of rice and sorghum. — Proc. Int. Seed Test. Ass. 35: 145—150. 1970.

No. 9. J. S. GUPTA & PAUL NEERGAARD: Detection of chlamydospores of Protomyces macrosporus Ung. in Indian seed lots of coriander. — Proc. Int. Seed Test. Ass. 35: 151—155. 1970.

No. 10. PAUL NEERGAARD, A. K. LAMBAT & S. B. MATHUR: Seed health testing of rice III. Testing procedures for detection of Pyricularia oryzae Cav. — Proc. Int. Seed Test. Ass. 35: 157—163. 1970.

No. 11. S. B. MATHUR & RAM NATH: Pestalotia guepini Desm. in seeds of Sorghum vulgare Pers. — Proc. Int. Seed Test. Ass. 35: 165—168. 1970.

No. 12. RAM NATH, S. B. MATHUR & PAUL NEERGAARD: Seed-borne fungi of mungbean (Phaseolus aureus Roxb.) from India and their significance. — Proc. Int. Seed Test. Ass. 35: 225—241. 1970.

No. 13. PAUL NEERGAARD: Seed-borne diseases and Indian agriculture. — Proc. Indian National Science Academy 36: 222—237. 1970.

No. 14. DHARAM VIR, S. B. MATHUR & PAUL NEERGAARD: Control of seed-borne infection of Drechslera spp. on barley, rice, and oats with Dithane M-45. — Indian Phytopath. 23: 570—572. 1970.

No. 15. M. C. SRINIVASAN, P. CHIDAMBARAM, S. B. MATHUR & PAUL NEERGAARD: A simple method for inducing sporulation in seed-borne fungi. — Trans. Br. Mycol. Soc. 56: 31—35. 1971.

No. 16. DHARAM VIR, S. B. MATHUR & PAUL NEERGAARD: Efficacy of certain fungicides against seed-borne infection of stackburn disease of rice caused by Trichoconis padwickii. — Indian Phytopath. 24: 343—346. 1971.

No. 17. P. A. SANTAMARIA, A. BENOIT & S. B. MATHUR: Curvularia cymbopogonis, a hitherto unreported species pathogenic to rice in the Philippines. — Pl. Dis. Reptr. 55: 349—350. 1971.

No. 18. PAUL NEERGAARD: International and national cooperation in seed health testing and certification. — Proc. Int. Seed Test. Ass. 37: 117—138. 1972.

No. 19. S. B. MATHUR & PAUL NEERGAARD: Seed health testing of rice. IV. Effect of light and temperature on seed-borne fungi in the blotter test. — Proc. Int. Seed Test. Ass. 37: 723—730. 1972.

No. 20. F. C. GUERRERO, S. B. MATHUR & PAUL NEERGAARD: Seed health testing of rice. V. Seed-borne fungi associated with abnormal seedlings of rice. — Proc. Int. Seed Test. Ass. 37: 985—997. 1972.

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Importance of *Drechslera maydis* on seed of crops other than maize

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Summary

Drechslera maydis (Helminthosporium maydis) was recorded in seeds of *Citrullus lanatus*, *Lactuca sativa*, *Paspalum scorbiculatum*, *Phaseolus aureus*, *Phaseolus mungo*, *Sorghum vulgare*, and *Vigna sinensis*, in percentages from 0.3 to 2.8. The infected seeds were from Ghana, India, Iran and Holland. The fungus did not produce disease on their respective hosts whereas all isolates produced mild to severe symptoms on standard differentials of maize. Five of the nine isolates tested were classified as Race T, four as Race O. Occurrence of Race T in Ghana and India is new for the respective countries The importance of inoculum on seeds of non-susceptible crops in spread of the fungus to new areas and in building up of inoculum is discussed.

Résumé

Importance de Drechslera maydis *chez les semences d'espèces cultivées autres que le maïs*

Drechslera maydis (Helminthosporium maydis) a été observé dans des semences de *Citrullus lanatus*, *Lactuca sativa*, *Paspalum scorbiculatum*, *Phaseolus aureus*, *Phaseolus mungo*, *Sorghum vulgare*, et *Vigna sinensis*, en pourcentages variant de 0,3 à 2,8. Les semences infectées provenaient du Ghana, de l'Inde, d'Iran, et des Pays-Bas. Les champignons n'ont pas produit de maladie chez leurs hôtes respectifs, mais tous les isolats ont provoqué des symptômes faibles à importants sur hôtes différentiels de maïs. Cinq des neufs isolats ont été classés comme appartenant à la Race T et quatre à la Race O. La présence de la Race T au Ghana et en Inde est nouvelle pour ces pays. L'importance des semences d'espèces non sensibles comme source d'inoculum pour la dispersion du parasite dans de nouvelles zones et pour l'accumulation d'un inoculum est discutée.

Zusammenfassung

Die Bedeutung von Drechslera maydis *für Samen von anderen Kulturarten als Mais*

Drechslera maydis (Helminthosporium maydis) wurde in Prozentsätzen von 0,3 bis 2,8 auf Samen von *Citrullus lanatus*, *Lactuca sativa*, *Paspalum scorbiculatum*, *Phaseolus aureus*, *Phaseolus mungo*, *Sorghum vulgare* und *Vigna sinensis* festgestellt. Die infizierten Samen stammten von Ghana, Indien, Iran und Holland. Die Pilze riefen keine Erkrankung auf ihren betreffenden Wirten hervor, während alle Isolate schwache bis schwere Symptome auf verschiedenen Maisstandardproben hervorriefen. Fünf der geprüften neun Isolate wurde als Rasse T, vier als Rasse O bestimmt. Das Vorkommen der Rasse T in Ghana und Indien ist neu für die betreffenden Länder. Die Bedeutung der Impfung von Samen nichtempfänglicher Kulturarten im Hinblick auf die Verbreitung der Pilze in neue Gebiete und auf den Aufbau einer Infektion wird diskutiert.

Introduction

Drechslera maydis (Nisik.) Subram. & Jain, the incitant of southern corn leaf blight, is world-wide in distribution. Until 1969 this fungus was grouped with other *Drechslera* species causing an average aggregate loss of 2.3% in maize (*Zea mays* L.) in the United States. In 1970 the disease became prominent causing more than 12% loss, equivalent to what is expected from all the diseases of maize, the widespread occurrence of the disease being the result of extensive building up of a new physiological race T, highly virulent on maize plants with Texas male-sterile cytoplasm.

In addition to field corn, sweet corn and pop corn, *D.maydis* has been reported also on other hosts in nature, e.g. *Sorghum halepense* (L.) Pers. and *S.guineense* (Mitra, 1931a; Tarr, 1962; Scott, 1971). Drechsler (1925) and Galloway (1936) isolated the fungus from teosinte (*Euchlaena mexicana* Schrad.) but they could not prove its pathogenicity on this host. Mitra (1931b) described *D.maydis* on ginger (*Zingiber officinale* Rosc.) from India. The fungus was pathogenic to ginger, but did not show any symptoms on other crops such as barley and wheat. Kovachich (1957) isolated the fungus from rotted leaves of oil palm and from a weed, *Sacrophrynium arnoldianum* (Marantaceae), in palm nurseries but was unable to reproduce the disease by inoculation. In Zambia *Cochliobolus heterostrophus* (Drechsl.) Drechsl., the perfect state of *D.maydis*, was recorded on *Panicum* (Ministry of Agriculture, Zambia, 1969).

A review of the literature indicates that there are only two cases where seeds of crops other than maize were found infected by *D.maydis*. The first was sorghum seeds, imported to India from Thailand, and intercepted by the Plant Introduction Division of the Indian Agricultural Research Institute (Ram Nath and Lambat, 1971). The second was pearl millet (*Pennisetum typhoides* Stapf. & Hubbard) seed, where one out of 22 samples investigated from the Agra district of India was found carrying 0.3% infection of *D.maydis*. It caused severe symptoms on pearl millet plants (Mathur, Ram Nath and Mathur, 1973).

During routine seed health testing of about 6000 seed samples of different crops at this Institute by the standard blotter method, seeds of seven crops other than maize were found infected by *D.maydis*, mostly in traces. Their pathogenicity was tested both on the hosts from which they were isolated, and on two maize differentials employed as standards for differentiating races. Results were compared with reactions of authentic cultures of Race O and Race T of *D.maydis*. The morphology of all the isolates was studied in detail and conidial measurements compared with those of the authentic cultures.

Materials and methods

D.maydis was recorded in seeds of different crops tested by the standard blotter method. Four hundred seeds of each sample were plated on three wet blotters, 25 seeds per plate. The plates were incubated at 20 $\pm$ 2°C under 12 hours alternating cycles of near ultraviolet light (NUV) and darkness for seven days and the seeds

examined on the eighth day under a stereoscopic microscope.

Habit characteristics of *D.maydis* growing on different seeds were recorded. Photographs of its growth were taken on seeds of some crops. Nine single spore isolations were made on PDA at 28 °C. Cultures thus obtained were compared with authentic specimens of *D.maydis* obtained from Dr. E. S. Luttrell, USA.

Pathogenicity of the nine isolates obtained from seeds of different crops, plus four from maize seeds and two authentic cultures of *D.maydis* from Dr. Luttrell was tested on 4-week-old plants of different crops by spraying spore suspension of 10-15-day-old cultures. The plants were raised in sterilised soil in a room where the temperature fluctuated between 21 ° and 27 °C, and daylight of 12 hours each day was provided by white fluorescent tubes (eight tubes of Philips TLF 40W/34; distance 80 cm from pots). Testing was first done on their original hosts and later on two differential cultivars of maize, 'FR 36' and 'FR 36 Trf' having normal and Texas male-sterile cytoplasm respectively. Seeds of the two differentials were supplied by Illinois Foundation Seeds, USA.

The inoculated plants were evaluated for disease reaction four days and eight days after inoculation. Three grades of disease severity were applied:

\+ Few restricted spots.
++ Reaction comparable to that of Race O.
+++ Reaction similar to that of Race T.

Isolations were made from the inoculated plants and their pathogenicity retested.

Results

The infection percentages of *D.maydis* encountered in seed samples of different crops are tabulated in table 1. Infection counts ranged from 0.3 to 2.8%. Because only

Table 1. Incidence of *Drechslera maydis* in untreated and pretreated seeds of different crops.

Sample no.	Host	Country of origin	Infection percentage in untreated seeds		Infection percentage in pretreated seeds
			1st testing	2nd testing	
1	Black gram (*Phaseolus mungo*)	India	0.5	0.3	0.3
2	Black gram (*Phaseolus mungo*)	India	1.0	1.0	0.3
3	Cowpea (*Vigna sinensis*)	India	0.3	0.8	0.3
4	Cowpea (*Vigna sinensis*)	Ghana	0.3	0.3	0
5	Green gram (*Phaseolus aureus*)	India	0.3	0	*
6	Lettuce (*Lactuca sativa*)	Holland	0.3	0	*
7	Paspalum (*Paspalum scorbiculatum*)	India	0.3	0.3	0
8	Sorghum (*Sorghum vulgare*)	Ghana	0.3	0.8	0.5
9	Watermelon (*Citrullus lanatus*)	Iran	2.8	2.5	2.0

* The sample could not be tested after chlorine pretreatment as seed supply was exhausted.

trace amounts of infection were found it was considered possible that the fungus might be contamination from infected maize seed samples tested at the Institute. Therefore, untreated seed, and seed pretreated with 2 % solution of sodium hypochlorite for 10 minutes, of all the nine infected samples was retested.

A. Incidence of Drechslera maydis in seeds

Seven out of nine samples tested again showed infection of *D.maydis*, while in two of the seed samples, one of green gram (*Phaseolus aureus* Roxb.) and the other of lettuce (*Lactuca sativa* L.), infection could not again be detected (table 1); and, unfortunately, these two seed samples could not be included in chlorine pretreatment because seed supply was exhausted. Out of seven samples tested after chlorine pretreatment five were still found infected, although with a reduced infection. These results indicate that the inoculum carried in seeds was well established.

B. Growth on seeds and measurement of conidia

The growth of *D.maydis* as observed after seven days of incubation on seeds of some of the crops along with that of maize is presented in figures 1–3.

The most severe infection was observed in sorghum seeds (figure 2). Seeds with profuse growth of the fungus usually did not germinate, and if germination occurred the coleoptile and radicle turned brown and were killed after 10–12 days of incubation. In seed samples of cowpea (*Vigna sinensis* (L.) Savi ex Hassk.) and watermelon (*Citrullus lanatus* (Thunb.) Matsumura et Nakai) blackish growth covering the entire infected seeds was seen by naked eye (figures 2–3). In the rest of the seed samples, that is green gram, lettuce and black gram (*Phaseolus mungo* L.), the fungus growth was moderate, either confined to the embryonal end or spreading all over the seed surface.

D.maydis is characterised by its typically curved, slender conidia which are borne acropleurogenously on dark conidiophores. This feature helped detection of this fungus on seeds of different crops. Growth of the fungus on seeds of these crops observed under stereoscopic microscope was essentially the same as that on maize, and different from the growth of closely related species, such as *Drechslera oryzae*. However, slight variations in colour, morphology of conidiophores and conidia were observed. Conidiophores of *D.maydis* which are normally medium to long and flexuous were short, more or less stiff with a swollen base in the isolate from *Paspalum*, while in all other isolates they were long and flexuous. The conidia presented shades of subhyaline to pale olivaceous brown colour in most of the isolates, while they were dark brown on watermelon. All the isolates produced abundant mycelium on PDA. Slight variations were observed in colour, curvature, size and septation of the conidia amongst the isolates (table 2). In all cases the conidial size increased on agar compared to their size on seeds.

The conidia of *D.oryzae* studied for comparison were smaller than the conidia of *D.maydis* (table 2).

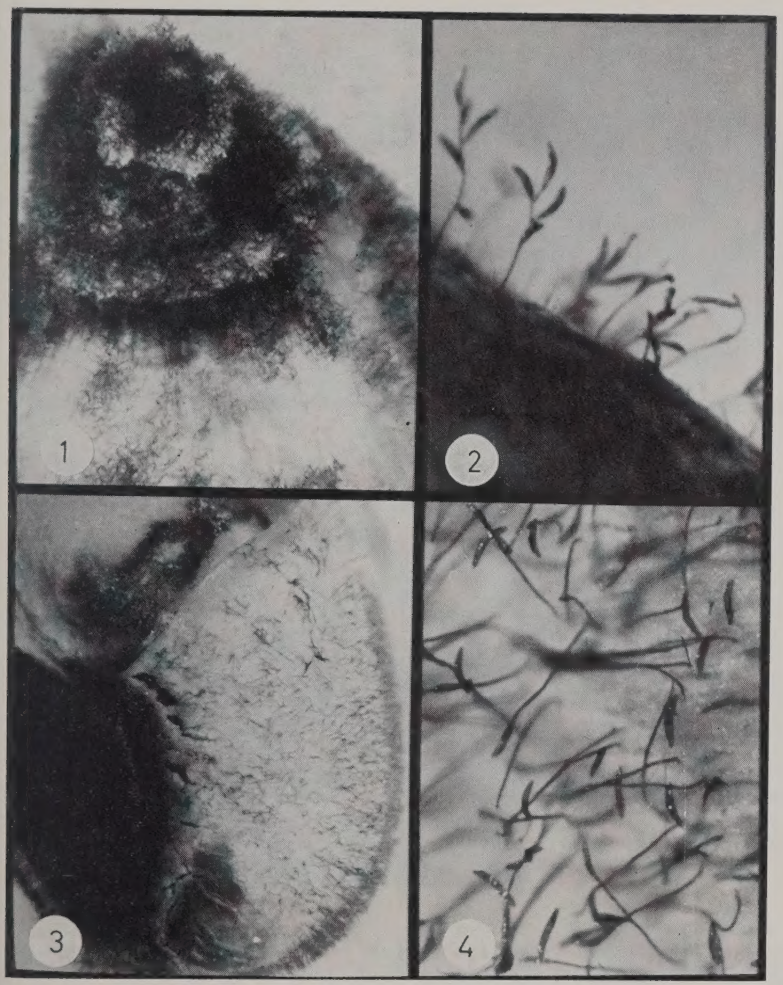

Fig. 1. Growth of *Drechslera maydis* on maize seed (1:20x), their conidia and conidiophores (2:175x), on seed of cowpea (3:20x) and their conidia and conidiophores (4:175x).

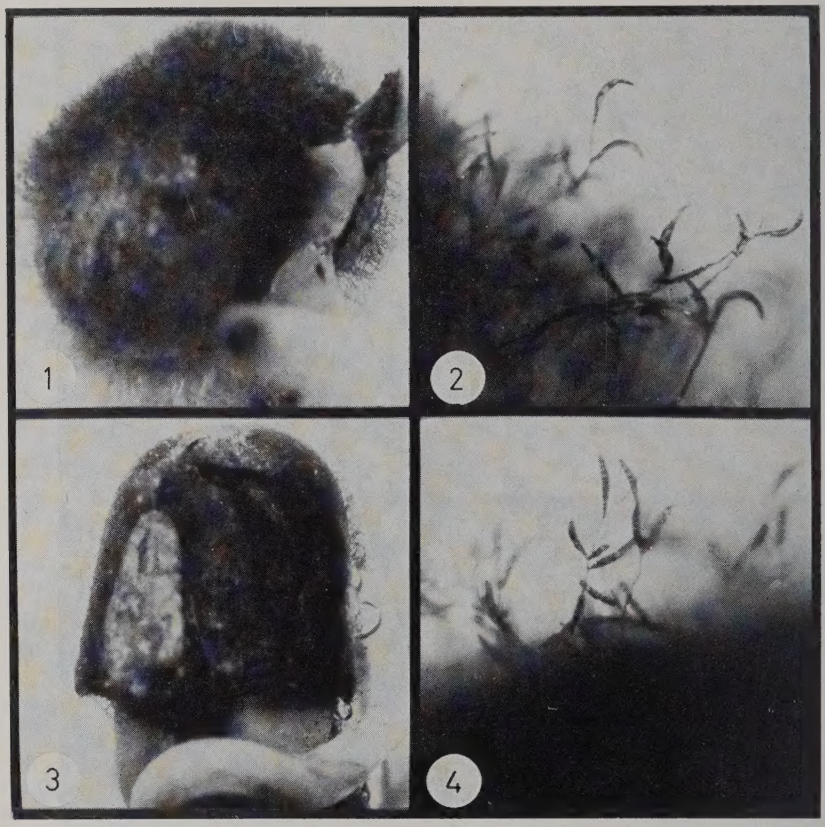

Fig. 2. Growth of *Drechslera maydis* on sorghum grain (1:20x), their conidia and conidiophores (2:175x), on seed of blackgram (3:20x) and their conidia and conidiophores (4:175x).

C. Pathogenicity

Only the isolates from cowpea and sorghum produced extremely mild symptoms in the form of scattered, minute, reddish brown flecks on leaves of their respective hosts, the rest did not. The reaction of authentic cultures of Race O and Race T on cowpea and sorghum was the same. On the other hand, all the nine isolates of *D.maydis* and authentic cultures of the two races produced mild to severe symptoms on maize.

Five out of the nine isolates tested were of Race T producing severe blight symptoms on maize plants with Tms cytoplasm. The remaining four belonged to Race O

Fig. 3. Growth of *Drechslera maydis* on watermelon seed (1: 20x), their conidia and conidiophores (2: 175x).

(table 3). Among the five isolates of Race T, the isolates from sorghum induced blight symptoms rather than inciting a leaf spot reaction on maize with normal cytoplasm.

The four isolates of *D.oryzae* produced very mild symptoms on maize plants (table 4). Few restricted, brown, oval 2–4 mm long, 2 mm wide spots appeared on the leaves which even 15 days after inoculation increased neither in number nor in size, whereas on rice they produced extensive spotting in leaves. Neither of the isolates produced any symptom on black gram, cowpea, lettuce, paspalum, sorghum, or watermelon.

Table 2. Measurements of conidia in millimicron of *Drechslera maydis* on seeds and potato dextrose agar (PDA).

Host	Length				Breadth				Septation			
	Range		Average		Range		Average		Range		Average	
	on seeds	on PDA	on seeds	on PDA	on seeds	on PDA	on seeds	on PDA	on seeds	on PDA	on seeds	on PDA
Black gram (isolate–1)	36– 98	68–131	76	102	12–18	12–17	14	15	5–10	6–11	7	8
Black gram (isolate–2)	62–114	81–147	92	107	14–17	12–17	15	14	5–10	7–10	8	11
Cowpea	60–109	78–145	83	111	12–17	12–18	14	15	6–9	6–10	7	8
Green gram	54–114	60–113	80	91	12–15	11–15	14	14	6–9	6–11	8	8
Lettuce	60–109	63–123	84	100	12–18	12–17	14	14	6–8	6–10	7	8
Paspalum	54–114	69–120	81	98	12–17	14–20	15	15	5–10	7–9	7	8
Sorghum	64–110	67–147	87	102	12–17	14–20	15	15	6–11	6–13	9	10
Watermelon	57– 96	69–105	75	88	14–20	14–23	17	18	6–9	6–9	8	8

Table 2. cont.

Measurements of conidia of authentic and other isolates from maize (on PDA)						
D.maydis Race O	65–114	88	12–17	14	6–10	8
D.maydis Race T	60–123	97	12–17	14	6–10	8
D.maydis Isolate–1	65–138	100	12–17	14	6–12	9
D.maydis Isolate–2	60–120	90	12–17	14	5–10	8
D.maydis Isolate–3	68–123	92	14–17	15	5–11	9
D.maydis Isolate–4	60–114	90	12–17	14	6–11	8
D.oryzae Isolate–1	65–90	77	14–18	16	6–10	7
D.oryzae Isolate–2	60–98	73	14–18	16	5–8	7
D.oryzae Isolate–3	50–111	74	15–18	17	6–9	7
D.oryzae Isolate–4	45–98	70	15–20	18	6–9	7

Table 3. Rating of pathogenicity and race identification of isolates of *Drechslera maydis*. Authentic cultures of Race O and Race T used for comparison.

Isolated from	Original host	Maize (N Cytoplasm)	Maize (Tms Cytoplasm)	Race identification
Black gram	—	++	+++	T
Black gram	—	++	+++	T
Cowpea	—	++	++	O
Cowpea	—	++	+++	T
Green gram	—	++	++	O
Lettuce	—	++	++	O
Paspalum	—	++	+++	T
Sorghum	—	+++	+++	T
Watermelon	—	++	++	O

— = No infection.
+ to +++ = Severity of infection.

Out of the four isolates of *D.maydis*, isolated from maize seed samples, two behaved like the authentic culture of Race O and two like that of Race T.

Discussion

A review of literature indicates that *D.maydis* has been known as seed-borne exclusively in maize. In two earlier reports, however, seeds of sorghum and pearl millet have been found infected (Ram Nath and Lambat, 1971; Mathur *et al.*, 1973). The present work is an additional report on *D.maydis* having been encountered on seeds of seven crops other than maize. Although the infection was in trace amounts, the explosive nature of the pathogen and widespread epidemics of southern corn leaf blight in 1970 throughout maize growing areas of the USA indicate that sowing of infected seeds should be avoided in uninfected areas. Once the fungus gets released in hitherto unreported areas, it may cause great losses attacking susceptible maize cultivars.

Table 4. Pathogenicity of isolates of *Drechslera maydis* and *Drechslera oryzae* from maize and rice respectively on type hosts and other hosts.

Pathogen / Host	*Drechslera oryzae*				*Drechslera maydis*				Authentic culture of *D. maydis*	
	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Race O	Race T
Maize N Cytoplasm	+	+	−	−	++	++	++	++	++	++
Maize Tms Cytoplasm	+	+	−	−	++	+++	++	+++	++	++
Rice	++	+++	++	++	−	−	−	−	−	−
Black gram	−	−	−	−	−	−	−	−	−	−
Cowpea	−	−	−	−	−	−	−	−	−	−
Lettuce	−	−	−	−	−	−	−	−	−	−
Paspalum	−	−	−	−	−	−	−	−	−	−
Sorghum	−	−	−	−	−	−	−	−	−	−
Watermelon	−	−	−	−	−	−	−	−	−	−

− = No infection.
+ to +++ = Severity of infection.

It is important to consider how the seeds of the different crops may have become infected in nature. Almost all the crops involved are either sown mixed or rotated with maize. Under such conditions there is a possibility that seeds may become contaminated either from air-borne or soil-borne (plant residue-borne) inoculum.

The caryopsis of sorghum and achene of lettuce are well exposed to the atmosphere during the entire period of development and maturity. In the remaining crop plants, the seeds are enclosed within the ovary wall which is dry at maturity in leguminous crops, but succulent in watermelon. In many countries threshing of leguminous seeds is carried out in the way cereal crops are threshed and usually at the same site. This provides opportunity for contamination. However, for watermelon chances for contamination in this way are remote due to protected seeds and selective threshing. This suggests a third possibility, namely that the pathogen may attack the fruits of the parent crop which in turn results in seed infection. However, there is no record of infection on these crops in nature.

The origin of Race T of *D.maydis* still remains controversial. It was first suggested that Race T is a mutant which became virulent on maize with Tms cytoplasm (Ullstrup, 1972). Nelson (1973), on the other hand, showed that Race T was present in almost all maize growing areas of the world as far back as 1955, and it was the widespread use of Tms cytoplasm in the United States that enabled the fungus to increase rapidly and produce epiphytotics. Ullstrup (1972) also suggested the possibility of introduction of this race into the USA from other countries where it already existed. Our results which have shown the occurrence of Race T in India and Ghana support the observations of Nelson (1973).

D.maydis has been recorded from India, but as far as the authors know this is the first record for Race T in that country. So far, maize cultivars with Tms cytoplasm are not in cultivation in India.

The recording of *D.maydis* on watermelon and lettuce seeds from Iran and Holland, respectively, is interesting as the pathogen has never been reported from these countries (CMI Map No. 346, 1969). Maize is grown in Iran but not in Holland. The lettuce seed sent from Holland to Pakistan must have been grown elsewhere (perhaps in southern Europe where lettuce seed is commonly grown on contract for seed companies in Holland and Denmark, and where also maize is grown).

Although it is well-known that Race T is severe on Tms cytoplasm there are reports that other cytoplasmic male-sterile corn, such as cms-HA, -P, and -Q, are susceptible to this race (Smith, Hooker, Lim and Beckett, 1971). Craig (1971) from Nigeria reported the susceptibility of a local maize cultivar 'NS-5' to Race T, whereas Danquah (1973) has shown that a local cultivar of maize from Ghana was highly susceptible. During the present study of the five Race T isolates, four gave normal reaction to maize differentials but the isolate from sorghum caused severe symptoms both on normal and Tms cytoplasm. Although this as well as other studies quoted above suggests the occurrence of some sort of genetic variability in Race T, possibly a third race is involved. Nevertheless, critical studies are required to confirm this. Nelson (1973), who from a world wide collection of *D.maydis* recovered 156 isolates of Race T, showed

that 126 were of one mating type.

It is important and relevant to international exchange of seeds that not only seeds of maize but also those of crops which are used in mix cropping or in rotation with maize, be examined with equal care in seed health testing and quarantine inspection. Obviously, pathogens may get entry into new areas, associated with seeds of the latter category. Lettuce seed recently introduced into Pakistan from Holland with infection of *D.maydis* was admitted due to the lack of consideration of pathogens on seeds other than maize. Fortunately, maize cultivars with susceptible cytoplasm are not grown in Pakistan, otherwise such a failure in import inspection could have had catastrophic consequences.

The assessment of seed-borne inoculum of *D.maydis* on seeds of crops encountered during the present study has been calculated in terms of number of inoculated loci per hectare (inoculum density) according to Neergaard (1962), see table 5. The inoculum thus introduced into a field may constitute a definite chance for its spread to maize.

Table 5. Calculation of inoculum density on the basis of infection percentages and seeding rate.

Crop	Infection percentage	Seeding rate per ha	No. of seeds per g	No. of inoculated loci per ha (inoculum density)
Black gram	1.00	2– 6.5 kg	25	500–1625
Green gram	0.25	10–27 kg	25	625–1687
Cowpea	0.50	30–60 kg	8	1200–2400
Paspalum	0.25	15–20 kg	240	9000–12000
Sorghum	0.50	10–40 kg	50	2500–10000
Watermelon	2.75	3–5 kg	11	908–1512

References

Commonwealth Mycological Institute (1969). *Distribution maps of plant diseases.* Map No. 346. C.M.I., Kew, Surrey, UK.

Craig, J. (1971). Occurrence of *Helminthosporium maydis* Race T in West Africa. *Pl. Dis. Reptr.*, **55**, 672–673.

Danquah, O.-A. (1973). *Studies on seed-borne fungi of rice, sorghum and maize from Ghana.* Danish Government Institute of Seed Pathology for Developing Countries, Copenhagen, Denmark.

Drechsler, C. (1925). Leaf spot of maize caused by *Ophiobolus heterostrophus* n.sp., the ascigerous stage of *Helminthosporium* exibiting bipolar germination. *J. agric. Res.*, **31**, 701–726.

Galloway, L. D. (1936). Report of Imperial Mycologist III. Diseases of crop plants. *Scient. Rep. agric. Res. Inst., Pusa*, 1934–35, 120–140.

Kovachich, W. G. (1957). Three leaf diseases of young oil palm associated with *Helminthosporium* species. *Trans. Br. mycol. Soc.*, **40**, 90–94.

Mathur, S. K., Ram Nath and Mathur, S. B. (1973). Seed-borne fungi of pearl millet (*Pennisetum typhoides*) and their significance. *Seed Sci. & Technol.*, **1**, 811–820.

Ministry of Agriculture, Zambia. (1969). Plant Pathology. *Rep. Res. Brch Minist. Agric. Zambia*, 1966, 34–46, 1967, 95–109. (*Rev. appl. Mycol.*, **48**, 3252).

Mitra, M. (1931a). Report of the Imperial Mycologist. *Scient. Rep. agric. Res. Inst., Pusa*, 1929–30, 58–71. (*Rev. appl. Mycol.*, **10**, 436–437).

Mitra, M. (1931b). A comparative study of species and strains of *Helminthosporium* on certain Indian cultivated crops. *Trans. Br. mycol. Soc.*, **15**, 254–293. (Rev. appl. Mycol., **10**, 758).

Neergaard, P. (1962). The infection percentage as a relative value in assessing disease tolerance for seed health testing. *Proc. int. Seed Test. Ass.*, **27**, 400–406.

Nelson, R. R. (1973). Further studies on the past occurrence and geographical distribution of isolates of Race T of *Helminthosporium maydis*. *Pl. Dis. Reptr.*, **57**, 18–19.

Ram Nath and Lambat, A. K. (1971). Fungi recorded on the imported seeds and other plant material in India. *Indian Phytopath.*, **24**, 189.

Scott, D. J. (1971). The importance to New Zealand of seed-borne infection of *Helminthosporium maydis*. *Pl. Dis. Reptr.*, **55**, 966–968.

Smith, D. R., Hooker, A. L., Lim, S. M. and Beckett, J. B. (1971). Disease reaction of thirty sources of cytoplasmic male-sterile corn to *Helminthosporium maydis* Race T. *Crop Sci.*, **11**, 772–773.

Tarr, S. A. J. (1962). *Diseases of sorghum, sudan grass, and broom corn*. Commonwealth Mycological Institute, Kew, Surrey, UK.

Ullstrup, A. J. (1972). The impacts of southern corn leaf blight epidemics of 1970–1971. *A. Rev. Phytopathol.*, **10**, 37–50.

No. 21. CHANG SIK KANG, PAUL NEERGAARD & S. B. MATHUR: Seed health testing of rice. VI. Detection of seed-borne fungi on blotters under different incubation conditions of light and temperature. — Proc. int. Seed Test. Ass. 37: 731—740. 1972.

No. 22. S. B. MATHUR, J. I. MALLYA & PAUL NEERGAARD: Seed-borne Infection of Trichoconis padwickii in rice, distribution, and damage to seeds and seedlings. — Proc. Int. Seed Test. Ass. 37: 803—810. 1972.

No. 23. V. K. AGARWAL, S. B. MATHUR & PAUL NEERGAARD: Some aspects of seed health testing with respect to seed-borne fungi of rice, wheat, blackgram, greengram and soybean grown in India. — Indian Phytopath. 25: 91—100. 1972.

No. 24. S. B. MATHUR & V. K. AGARWAL: A Pestalotia sp. causing fruit rot in apple. — Friesia 10: 57—60. 1973.

No. 25. N. FABRITIUS BUCHWALD & PAUL NEERGAARD: A plea for the retention of Sclerotinia sclerotiorum as type species for the genus Sclerotinia Fckl.emend. — Friesia 10: 96—99. 1973.

No. 26. P. CHIDAMBARAM, S. B. MATHUR & PAUL NEERGAARD: Identification of seed-borne Drechslera species. — Friesia 10: 165—207. 1973.

No. 27. PAUL NEERGAARD: Detection of seed-borne pathogens by culture tests. — Seed Sci. & Technol. 1: 217—254. 1973.

No. 28. THU HA NGUYEN, PAUL NEERGAARD & S. B. MATHUR: Seed-borne species of Myrothecium and their pathogenic potential. — Trans. Br. Mycol. Soc. 61: 347—354. 1973.

No. 29. S. K. MATHUR, RAM NATH & S. B. MATHUR: Seedborne fungi of pearl millet (Pennisetum typhoides) and their significance. — Seed Sci. & Technol. 1: 811—820. 1973.

No. 30. M. C. SRINIVASAN, PAUL NEERGAARD & S. B. MATHUR: A technique for detection of Xanthomonas campestris in routine seed health testing of crucifers. — Seed Sci. & Technol. 1: 853—859. 1973.

No. 31. PAUL NEERGAARD: Seed health — Policy of certification and disease control. — Seed Pathology News No. 6: 7—9. 1974. Reprint 7 p.

No. 32. H. C. PHATAK: Seed-borne plant viruses — Identification and diagnosis in seed health testing. — Seed Sci. & Technol. 2: 3—155. 1974. (Inserted Danish summary. 5 p.)

No. 33. WALTER E. WINTER, S. B. MATHUR & PAUL NEERGAARD: Seed-borne organisms of Argentina: A survey. — Pl. Dis. Reptr. 58: 507—511. 1974.

No. 34. CHINENYE NWIGWE: Effect of Diplodia zeae and β-Phomopsis on the germination of seeds of maize (Zea mays), and Occurrence of Phomopsis on maize (Zea mays). — Pl. Dis. Reptr. 58: 414—415; 416—417. 1974.

No. 35. D. V. SINGH, S. B. MATHUR & PAUL NEERGAARD: Seed health testing of maize. Evaluation of testing techniques, with special reference to Drechslera maydis. — Seed Sci. & Technol. 2: 349—365. 1974.

No. 36. D. V. SINGH, S. B. MATHUR & PAUL NEERGAARD: Race identification of Drechslera maydis in maize seed lots from different countries. — Seed Sci. & Technol. 2: 367—370. 1974.

No. 37. R. FATIMA, S. B. MATHUR & PAUL NEERGAARD: Importance of Drechslera maydis on seed of crops other than maize. — Seed Sci. & Technol. 2: 371—383. 1974.

No. 38. K. S. AULAKH, S. B. MATHUR & PAUL NEERGAARD: Comparison of seed-borne infection of Drechslera oryzae as recorded on blotter and in soil. — Seed Sci. & Technol. 2: 385—391. 1974.

No. 39. K. S. AULAKH, S. B. MATHUR & PAUL NEERGAARD: Seed health testing of rice and comparison of field incidence with laboratory counts of Drechslera oryzae and Pyricularia oryzae. — Seed Sci. & Technol. 2: 393—398. 1974.

No. 40. DALBIR SINGH: Occurrence and histology of hollow heart and marsh spot in peas. — Seed Sci. & Technol. 2: 443—456. 1974.

No. 41. CHALERMLARB CHUAIPRASIT, S. B. MATHUR & PAUL NEERGAARD: The light factor in seed health testing. — Seed Sci. & Technol. 2: 457—475. 1974.

No. 42. S. A. JAMIL KHAN, S. B. MATHUR & PAUL NEERGAARD: Survey on new seed-borne organisms of Pakistan. — Seed Sci. & Technol. 2: 477—479. 1974.

No. 43. DALBIR SINGH & SUDHIR K. MATHUR: Sclerotium rolfsii in seeds of bean from Uganda. — Seed Sci. & Technol. 2: 481—483. 1974.